

# PATENT SPECIFICATION

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## DRAWINGS ATTACHED

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## (54) APPARATUS FOR MEASURING O<sub>2</sub> CONCENTRATIONS IN GASES

(71) We, VEB KOMBINAT MESS-UND  
REGELUNGSTECHNIK DESSAU, a corporation  
organised under the laws of Eastern Germany,  
of 43, Altenerstrasse, 45 Dessau, Germany, do  
hereby declare the invention for which we  
pray that a patent may be granted to us, and  
the method by which it is to be performed,  
to be particularly described in and by the  
following statement:—

10 The invention relates to a measuring ap-  
paratus for accurately measuring O<sub>2</sub> concen-  
trations in gases by means of physical measur-  
ing detectors.

15 With physical analysis of substances, the  
measurement effects often appear masked by  
disturbing effects.

20 In connection with thermomagnetic O<sub>2</sub>-  
analysis, some properties of the residual gas  
admixed with the oxygen are for example  
also included. The exclusion of the disturbing  
effect of the carrier gas is a very important  
problem in the development of systems of  
physical analysis of O<sub>2</sub>.

25 Especially for the analysis of oxygen, ap-  
paratus are known which use measuring  
detectors, with which the magnetic suscepti-  
bility is directly measured, isolated from dis-  
turbance influences. These measuring detectors  
have not proved satisfactory when working  
under rough conditions. They are sensitive  
to dust particles, show an unfavourable be-  
haviour as a function of time and are rela-  
tively costly to manufacture.

35 It is also known that disturbing of carrier  
gas effects may be excluded by incorporating  
special thermal auxiliary measuring detectors  
in the same measuring unit and measuring  
gas stream with the thermomagnetic O<sub>2</sub>  
measuring detector and in this way a reduc-  
tion of the interfering influence is obtained  
for small changes in carrier gas and changes  
in O<sub>2</sub> concentration.

45 The connection in opposition of two volt-  
ages of different measuring detectors does  
not give any comprehensive compensation of  
the disturbing effects and involves an in-

dividual adaptation of the measuring installa-  
tion to the actual case of operation. The  
relatively troublesome method is not satis-  
factory in practice.

50 In the industrial measuring art, the thermo-  
magnetic measurement of O<sub>2</sub> by the annular  
chamber principle has proved satisfactory.  
The dependence occurring therewith of the  
output voltage on the so-called carrier gas

55  $SH \cdot d$   
factor  $\frac{SH \cdot d}{kv}$  can however lead to measure-

ment errors between 60% too small a  
measurement and 500% too large a measure-  
ment. In the formula:

$SH$  represents specific heat } of the gas  
 $d$  = density } mixture to  
 $kv$  = kinetic viscosity } be tested

60 In order nevertheless to obtain accurate  
analysis values, only strictly limited fluctua-  
tions in the carrier gas composition are per-  
mitted in practice.

65 In the textbook entitled "Messen und  
Regeln in der Chemischen Technik"  
("Measuring and Regulating Processes in  
Chemical Engineering"), published by  
Springer (Berlin/Göttingen/Heidelberg),  
1964, pp. 532—534, the function of thermo-  
magnetic O<sub>2</sub> analysers is described, which  
have no additional interfering convection  
effect.

75 Additional interfering convection forms a  
supplementary influence and has to be elimin-  
ated by a counter-connection with a compara-  
tive cell. In the apparatus according to the  
present invention additional interference from  
convection does not occur.

80 In all thermo-magnetic measuring processes,  
however, a further interference occurs by the  
product of the O<sub>2</sub>-governed part of the signal  
and the carrier gas factor. If the characteristic  
data  $K$  of a measuring detector are regarded  
as constant, then the equation (on simplified  
lines) is as follows;

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$$\text{Measuring signal } e = K \cdot p \text{ O}_2 \cdot \frac{\text{SH} \cdot d}{kv}$$

Where  $p \text{ O}_2$  = real  $\text{O}_2$  concentration in vol. %.

The main object of the present invention is thus to eliminate the faults occurring by multiplication of factors, the so-called carrier-gas effect. The thermomagnetic measuring detectors adopted will be of the type not having any supplementary additive convection interference effect.

According to the present invention there is provided a measuring apparatus for the accurate detection of  $\text{O}_2$  concentration in a gas, comprising a thermo-magnetic apparatus having two measuring chambers, a first detector in the first chamber for forming a signal which is proportional to the product of the  $\text{O}_2$  concentration and the interference influence of a carrier gas, the  $\text{O}_2$  concentration of which is to be detected, and a second detector in the second chamber for forming a signal proportional to the interference influence, the measuring apparatus further comprising means for deriving from the signals from said detectors a resultant equivalent to the signal of said first detector divided by the signal of the second detector, and wherein the ends of a U-shaped tubular passage of said second chamber are connected to a differential pressure regulator which is connected to an absolute pressure regulator.

In the simplest form, the evaluation of the signals is effected by a recording of two instantaneous values. The obtaining of the analysis value without dependence on the carrier gas factor is effected by division of the two actual instantaneous values.

It is also possible to effect the automatic correction, utilising the two measurement signals, in an analogue computer.

If a suitable digital computing arrangement is provided for the detection of the complex numerical measurement data, then it is possible for the two measurement signals to be converted into a digital form and for a digital quotient formation to be carried out.

A constructional embodiment of the invention will now be described, by way of example, with reference to the accompanying drawing which shows diagrammatically an apparatus according to the invention.

The measuring apparatus comprises two similar detectors or sensors 1, 11, a differential pressure regulator 18, an absolute-pressure regulator 22 for the measuring gas, gas-connection conduits, a computer shown schematically, having an indicator, and with electric voltage-sources.

The sensor 1, with channel borings 2, two measuring tubes 3, attached to the interior of the channel borings with adhesive in a

gastight manner and having heating coils 4, 5, 6 and 7, measuring-gas sample conduit 8 situated transversally to the channel borings, a double pair of pole pieces 9, with a magnet system (not shown) and with ducts 10, is used as the  $\text{O}_2$  measuring sensor.

The sensor 11 differs from the sensor 1 by the omission of the magnetic system with the pole pieces. In addition, the gas conduits are differently arranged and connected.

Both sensors, the differential pressure regulator 18 and the absolute-pressure regulator 22 for the measuring gas are interconnected by gas conduits 12, 13, 14 and 15. Heating resistances in both sensors are in each case connected to form Wheatstone bridges.

The gas to be examined passes through the sensor 1 and the sensor 11. The laminar choke 20 serves to limit the quantity flowing through the sensor 1. The thermo-magnetic wind produces, in the two tubes 3 of the measuring sensor 1, a differential pressure which is proportional to the  $\text{O}_2$  content. This pressure is of the order of magnitude of  $10^{-2}$  mm (wat.col.) and cannot be measured direct except at the cost of considerable apparatus and labour. The flow which it produces in the tubes is therefore measured. To carry out all measurements at the same absolute pressure the absolute pressure regulator 22 is connected into the measuring gas feed conduit. In this process the composition of the carrier gas influences the sensitivity of the measuring apparatus. In order to measure this effect, the differential pressure in the sensor 11 is kept constant for all gases.

The output signal is then proportional to the change caused in the sensitivity of the measuring sensor by the carrier gas. The pressure in the sensor 11 is likewise in the order of magnitude of  $10^{-2}$  mm (wat.col.). By the aid of the laminar chokes 19 and 21, the output pressure of the differential pressure regulator 18, which contains the two tubes 16 and 17, is reduced from about 50 mm (wat.col.) to the extent required to ensure that the required differential pressure prevails.

The dual arrangement of the measuring tubes in the two measuring chambers ensures that no thermal convection causing interference can occur, because the thermal buoyancy forces in the two tubes are in each case equal and take the opposite direction to each other.

The apparatus includes an electrically heated thermostatically controlled chamber (not shown) which surrounds both measuring sensors.

The inaccuracy of the measurement information which is possible with the physical oxygen measuring installation as described falls from formerly  $-60\%$  to  $+500\%$ , to within a few percent of the actual value.

## WHAT WE CLAIM IS:—

1. A measuring apparatus for the accurate detection of  $O_2$  concentration in a gas, comprising a thermo-magnetic apparatus having two measuring chambers, a first detector in the first chamber for forming a signal which is proportional to the product of the  $O_2$  concentration and the interference influence of a carrier gas, the  $O_2$  concentration of which is to be detected, and a second detector in the second chamber for forming a signal proportional to the interference influence, the measuring apparatus further comprising means for deriving from the signals from said detectors a resultant equivalent to the signal of said first detector divided by the signal of the second detector, and wherein the ends of a U-shaped tubular passage of said second chamber are connected to a differential pressure regulator which is connected to an absolute pressure regulator.
2. A measuring apparatus as claimed in claim 1 wherein each chamber comprises a bored body portion and two parallel tubes hermetically mounted in said body portion, one end of each tube communicating with a conduit for the gas to be measured and each tube being surrounded by a heating coil having a central tap, a pole piece being provided at right angles to one end of each coil in the first chamber and the said one ends of the tubes of the second chamber being connected to said conduit by respective laminar chokes.
3. A measuring apparatus as claimed in claim 1 or 2 wherein both measuring chambers are mounted within an electrically heated thermostatically controlled chamber.
4. A measuring apparatus substantially as herein described with reference to and as illustrated by the accompanying drawing.

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COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of  
the Original on a reduced scale

